

3 Survey Equipment

Procurement and maintenance of surveying equipment, tools and supplies are important parts of the Caltrans survey effort. Proper use, storage, transportation and adjustment of equipment are major factors in the successful completion of a survey.

This Chapter provides policy, procedure and general information on procurement, control and maintenance of survey equipment, tools and supplies.

3.1 Policy Concerning Personal Use of State Property

Any State employee who misuses State equipment or property is subject to adverse action. Misuse includes taking State equipment or property without authorization, damaging or losing it through lack of care, or using it for personal business.

3.2 Procurement of Equipment and Supplies

3.2-1 Sources of Supply

The following prioritized sources should be considered for supplies. The Division of Procurement and Contracts (DPAC) can help you determine which source is most appropriate.

Local Inventory: Always check supplies on hand before placing orders.

District Warehouse: Review the District Warehouse (or Stockroom) catalogs for items needed.

Surplus Elsewhere in the District (or in another District): A reasonable effort must be made to utilize excess stock within the District/Region before purchasing additional items.

DPAC Warehouse: The DPAC Warehouse provides supplies for the daily operating needs of the Department and stocks a wide variety of items in its warehouse in Sacramento. The warehouse stocks most common surveying supplies and equipment such as rods, steel tapes, paint, flagging, stakes, nails, shiners, etc. It also stocks Caltrans manuals, publications and forms. Some districts have direct access to the DPAC through the Caltrans network. Check with the DPAC for direct access questions.

Department of General Services (DGS) – Materiel Services:

Materials not available from the DPAC Warehouse must be ordered from this source, if available. Examples of the DGS Materiel Services Warehouse inventory are: State forms, janitorial products and publications.

Prison Industry Authority (PIA): Some items produced by PIA include orange coveralls, shirts, vests, other apparel items, work gloves, safety glasses and office furniture. Many PIA items are stocked in District & DPAC warehouses. PIA publishes a product catalogue. Prior to commercial procurement of items similar to those produced by PIA, a written waiver must be obtained from PIA.

3.2-2 State Contracts

State Contracts: Statewide contracts are awarded by competitive bid for certain volume commodities. Except in emergency situations, purchases of contract commodities cannot be made from outside the contract process.

State Price Schedules, California Multiple Award Schedules (CMAS) or California State Computer Stores: Some commodities can be ordered from suppliers who have negotiated agreements with the Department of General Services (DGS) to supply products at a guaranteed price. These programs are optional but purchasing equipment up to a specific amount through CMAS or the State Computer Store can be done without using the DGS formal bid process. Contact the DPAC for advice on using these programs. Refer to the CMAS web site for details and guidelines:
<http://www.pd.dgs.ca.gov/cmas/contracts.htm>

Outside Vendors: Materials not available from the above-named sources can be purchased using Purchase Requests, or Cal-Card Visa. DGS has delegated a general purchase authority up to specific amounts to the Department. Purchases over the specific limit require

a formal DGS bid process. For purchases over the limit, consult with the DPAC and consider using CMAS or the State Computer Store.

3.2-3 Caltrans Cal-Card Small Purchase Program

Materials, supplies and services obtained from outside vendors should be purchased using the Caltrans CAL-Card Small Purchase Program because it expedites payment and reduces paperwork. There is a purchase limit for the CAL-Card for purchases and for each service order, with a specific limit for service orders per year for any one vendor. Cards are issued to individuals, who are responsible for the use of the card. For applications for cards and copies of the “Caltrans CAL-Card Handbook,” contact the DPAC or Refer to the DCPA Cal Card web site for details and guidelines:

http://onramp.dot.ca.gov/hq/accounting/visa/publications/PCARS_Handbook_0705.doc

3.3 Equipment Control Following Acquisition

The *State Administrative Manual* (SAM) governs control of equipment. For information on property control, refer to SAM or contact the Property Control Unit.

3.3-1 Classes of Property

Equipment, materials, and supplies are categorized as expendable or non-expendable. Expendable is defined as material or equipment normally consumed while in service. Examples of expendable equipment are tools such as shovels. Non-expendable material or equipment is not consumed in service and is expected to have a life expectancy of one or more years. Some examples of non-expendable equipment are survey instruments, chain saws, and computers.

Equipment with a value exceeding \$500 is generally assigned a Caltrans property ID number and tagged by the Office of Land Surveys or the Property Control Unit. The property ID number on the tag is used to inventory equipment.

3.3-2 **Inventory of Equipment**

The SAM mandates an accounting of all non-expendable property every three years. To facilitate this triennial inventory, each Surveys Branch should maintain an inventory of all non-expendable equipment and accessories. A person other than the Equipment Coordinator must perform the triennial inventory. The person performing the inventory must sign and date the inventory records. Completion of the triennial inventory is the responsibility of the Office of Land Surveys, the Property Control Unit, and the District/Region Survey Manager.

The Office of Land Surveys maintains a master inventory of all equipment and accessories that it has acquired and issued to the District Surveys Offices. Control of this equipment and its accessories is the responsibility of the District/Region Survey Manager and any change in status should be reported to the Office of Land Surveys.

3.3-3 **Transfers of Non-Expendable Property**

Equipment Transfer or Loan within the District Surveys Office:

Record keeping for this type of property transfer is very important. If transfers are made without documentation, the person who ships the equipment will remain responsible for it until the paperwork is properly submitted. For this reason all equipment transfers should be recorded using a New Equipment Identification, Transfer and Accountability Record (Form ADM 2029). Copies of the fully-completed ADM 2029 shall be distributed to all involved parties.

Equipment Transfer or Loan to Other Functions Within District:

Loans of surveying equipment to other district functions may be made at the discretion of the District/Region Survey Manager. Before any loans are made, the District/Region Survey Manager should consider employee and public safety as well as overall efficiency of survey operations. Loans of survey equipment should be recorded using form ADM 2029.

Equipment Transfer or Loan to Other Districts or State Agencies:

The transfer or loan of non-expendable property owned by the Office of Land Surveys between Districts or between a District and another state agency requires Office of Land Surveys approval. No transfer should be undertaken without preparing a Form ADM 2029.

3.3-4 Disposal of Outdated Equipment

Equipment no longer suitable for use by the Department because it is worn, broken, deteriorated, or obsolete is retired by DGS sale, trade-in, donation to a state-funded public entity, or recycling.

Proposed retirement of non-expendable equipment should first be discussed with the Equipment Coordinator of the Office of Land Surveys. The District/Region Survey Manager is responsible for retiring equipment and properly preparing a Request For Property Survey (Form ADM-0395) and submitting it to the Property Control Unit. The Office of Land Surveys will initiate retirement of equipment it owns after all necessary data is received from the District/Region Surveys Manager.

3.3-5 Individual Responsibility

Each employee has a responsibility to “reasonably” care for State equipment. An employee who is determined to be “negligent” in the level of care provided for equipment may face serious consequences.

Black’s Law Dictionary, 8th Ed., defines “negligence” as: “The failure to exercise the standard of care that a reasonably prudent person would have exercised in a similar situation.”

In the event that equipment is lost, damaged, or stolen, and an employee is determined to be “negligent” in that loss, the Property Survey Board may recommend that the employee be required to reimburse the Department for the value of the equipment, or a portion thereof, or face disciplinary action.

3.3-6 Lost, Stolen, or Damaged Survey Equipment

Whenever State-owned equipment is lost, stolen, vandalized or otherwise damaged, the employee assigned the equipment must:

- Except in the case of accidental damage, immediately contact the California Highway Patrol and the law enforcement agency with jurisdiction in the area where the loss occurred.
- Notify the first-line supervisor and the District Security Coordinator.
- Complete a Report of Lost, Stolen, or Damaged State-Owned Property (Form ADM-0396), or its equivalent.

Form ADM-0396 should be carefully filled out. If the form is not immediately available, record the:

- Description of the equipment (make, model, serial number, property ID number, etc.) including, if known, original cost or replacement cost with supplementary costs such as shipping and installation.
- Circumstances of the loss, damage, or crime including the date and time.
- Name of employee reporting the loss.
- Highway Patrol or police report number.

The employee should submit the report (or equivalent information) to the employee's first-line supervisor. The first-line supervisor will review, sign and add the following information to the report:

- Acceptability of the report made by the employee.
- Precautions taken to prevent the loss.
- The degree of culpability of the employee and whether negligence was involved.

The final report (ADM-0396) is then sent to the District/Region Survey Manager for review before submission to the Property Unit. If the equipment involved was originally acquired by the Office of Land Surveys, a copy of the report shall be forwarded to the Office of Land Surveys.

3.5 Surveying Instruments

Caltrans survey crews are provided state-of-the-art surveying instruments. Following are typical survey instruments used by Caltrans survey crews:

- Data Collectors/Survey System Controllers, software and accessories.
- Total Station Survey System with accessories.
- Global Positioning System (GPS) receivers with real-time data links, and accessories.
- Leveling Systems (automatic optical pendulum and digital bar code reading) and accessories.
- Field and office computers.

3.5-1 General

Survey Instrument Operators Manuals

Each instrument is furnished with an operator's manual, a copy of which should be filed in the Surveys office. The manual contains a description of the instrument, specifications, and basic operating instructions along with recommended servicing and adjusting intervals and methods. The operator's manual should be kept with the instrument at all times, and thoroughly studied prior to use of the instrument, particularly when prescribed field checks and adjustments are to be made. Notes collected during adjustment procedures should be included in field notes that will be permanently archived. (See Chapter 14, "Survey Records")

Transport and Storage of Survey Instruments

For transport of an instrument by road or air, use shockproof casing or packing materials to protect the instrument from excessive vibration. If at all possible, retain and reuse the original manufacturer's packaging system. Store instruments in a position consistent with the design of its carrying case.

Electrical Power Sources, Use and Maintenance

A DC power source is required to power electronic instruments and data collection units. Batteries are supplied with instruments. For 12-volt

instruments, any source of 12v DC power can be utilized. A clip-on power cable may be provided for use with an automotive battery. Such cables must have fused protection against reverse polarity. Transport batteries in a suitable location. Do not transport batteries with loose objects that could possibly contact the battery terminals.

There are various types and models of batteries in use, including NiCd, NiMH, and lithium ion. Select the proper charger provided by the instrument manufacturer or an approved battery charger, based on the voltage and amp-hour rating of the battery. Do not interchange battery chargers. Follow the manufacturers recommended procedures for maintaining best operating parameters.

Use care when connecting or disconnecting power or data cables to or from a survey instrument, GPS receiver, or survey data collector. To connect the cable, carefully align the index marks on the connector with those on the receptacle. To disconnect the cable, grasp the connector, not the cable. Damage to cables and connectors may be considered negligence.

Routine Maintenance and Care of Survey Instruments

Before using an instrument, visually inspect it for damage. Check all machined surfaces including the polished faces of lenses. Check instrument motions for smooth operation.

Clean the instrument exterior frequently in accordance with manufacturer's recommended procedures. Accumulation of dirt and dust can mar machined or polished surfaces and cause friction and uneven motion in the horizontal and vertical movements. Remove dust with a camel's-hair brush, then clean soiled non-optical parts with a soft cloth or with a clean chamois. Clean external lens surfaces with a fine lens brush. If necessary, use lens tissue. Do not use silicone treated tissue that can damage coated optics; do not use any liquids other than pure alcohol. Take care not to scratch lenses or their coating. Never touch optical glass with your fingers. Do not loosen or attempt to clean the internal surface of any lens.

If an instrument has become wet, unpack it at the end of the day and, after wiping dry with a soft towel or cloth, leave the instrument and any of its accessories outside of the case to dry. Also leave the case open to dry. If the foam inserts for the case are wet, also remove them for drying. Do not replace the instrument in the case until completely dry.

Service and Repair of Survey Instruments

Periodic servicing, repair or complex adjustments shall be accomplished by authorized service facilities. Service contracts for maintenance and repair of survey instruments and accessories are negotiated through a competitive bid process and administered by the Office of Land Surveys. All service, maintenance, and repair of survey instruments and accessories must be approved by the Office of Land Surveys. Instruments covered by a service and repair contract shall not be serviced by any other means. The following Caltrans' survey instruments are generally covered by state-administered service contracts:

- Data Collectors/Survey System Controllers and accessories
- Total station survey systems and accessories
- GPS receivers and accessories
- Digital bar-code levels

Maintenance Schedules & Record Keeping for Instruments:

Refer to each instrument operator's manual to determine if the manufacturer suggests scheduled service intervals. Total stations should be serviced approximately once every eighteen months. All instruments (or accessories) should be serviced when:

- The instrument or accessory is inoperative.
- The instrument or accessory is damaged.
- The instrument or accessory does not maintain adjustment(s).
- Mechanical adjustments are stiff or binding.
- Optics are fogged or cloudy.

Each District Survey Equipment Coordinator, in conjunction with the District's party chiefs, should maintain records detailing the frequency of service for each survey instrument.

Use of State-Administered Service Contracts:

To service or repair an instrument, contact the Office of Land Surveys and obtain a work order for the instrument repair. Complete a Survey Equipment Work Order form (Form DTFD-GEO-1) and include the instrument and accessories serial numbers and property ID numbers on the form. Provide a description of problem(s) encountered with the instrument and/or accessories and include specific instructions for

requested repair services. Also include the requester's phone number. Distribute copies of the Work Order Form as indicated on the form. A shipping address for the designated service facility will be furnished if requested.

Note: Ship instruments in their transport cases. When possible, ship instruments in the original manufacturers' shipping cases. Pack all other instruments and accessories in a sturdy shipping box with adequate cushioning material between their transport case and shipping box.

Service/Repair Limits: Service/Repair Cost vs. Remaining Value:

All OLS-administered service contracts specify that written estimates are required.

Generally, instruments should be retired when estimated service cost exceeds estimated value after service. The determination of when to retire, rather than service an instrument, shall be made by the Office of Land Surveys and based on the following factors:

- Cost of servicing.
- Obsolescence of instrument.
- Past service records.
- Availability of parts.
- Availability and cost of new instruments.
- General condition of instrument.

Service/Repair of Other Survey Equipment:

Before requesting service/repair of any survey equipment:

- Check manufacturers' warranties.
- Be sure that service does not cost more than replacement.

Service for survey equipment not covered by state-administered service contracts may be provided by:

- Manufacturers' warranties.
- Department-wide service contracts.

- Individual service contracts negotiated with a manufacturer or dealer for specific instruments.
- Use of the CAL-CARD credit card for service on an as-needed basis.
- Caltrans or General Services service facilities

3.5-2 Data Collector Systems

Current surveying equipment technology is centered on collecting data and using data in conjunction with various survey instruments and systems. The latest technology data collectors are essentially fully functioning, ruggedized handheld computers. The data collection software can perform coordinate geometry computations and other calculations. Measured values captured by the total station, GPS receiver, or digital level can be displayed numerically and/or graphically and recorded in the data collector and later downloaded to another computer. Stakeout computations are also generated in the data collector, and sent to the total station. Stakeout information can be numerically and/or graphically displayed when using either a total station or GPS receiver.

Data Collector Systems include:

- Hardware, either on-board an instrument or an external device
- Data Collection software
- A means of communication between the various survey instruments or equipment and the device.
- Accessories (such as batteries and chargers, prism/rover pole bracket, and other miscellaneous accessories)

3.5-3 Total Station Survey Systems (TSSS)

Field components of TSSS systems include:

- Total station
- Data collection system
- Laptop computer
- Various Cables
- Accessories (such as tripods, tribrachs, batteries and chargers, prism poles, and other miscellaneous accessories)

Total Station

The typical Caltrans total station is capable of precisely measuring horizontal angles, vertical angles, and slope distances. The instrument may be provided with onboard software and/or the capability to connect to an external data collector.

Field Operations

Precautions to take when operating a total station include:

- Do not leave instruments unprotected or unattended, in unsecured areas.
- Do not carry tripod-mounted instruments over the shoulder
- Remove instruments from the tripod when changing set-up locations
- Calibrate per manufacturer's recommended daily procedures
- Ensure the instrument prism offset value is set correctly for the prism(s) in use
- Ensure that the latest version of the instrument's firmware have been installed
- Never point the telescope directly at the sun. The sun's rays may damage the electronic distance measuring (EDM) circuitry.
- If possible, shade the instrument from direct sunlight as excess heat may reduce the range of the sender diodes in the EDM circuitry.
- To maintain maximum signal return at longer ranges, shade prisms from direct sunlight.
- Avoid multiple, unrelated prisms in the same field of view; this can cause blunders in distance observations.
- Most total stations are equipped to detect and correct various instrumental errors. If such errors exceed program limits, error codes will indicate the error. Consult the operator's manual for exact procedures and error code definitions.
- When possible, select instrument setup locations to minimize the exposure of the instrument operator, other members of the crew, and the instrument to danger. Select stable ground or footing for the tripod feet. Do not set an instrument directly in front of or behind a vehicle or piece of construction equipment that may suddenly move.

- In the event that the instrument or any personnel are required to be in an area subject to traffic, protection procedures outlined in Section 2, “Safety,” must be followed.

Prisms

Several types of prisms are available within Caltrans inventory, including standard prisms, mini prisms, and 360° prisms. Each prism will likely have a different prism offset value. To obtain accurate survey results, it is essential to set the instrument to the correct prism offset value for the prism(s) in use. If using a total station with an external data collector, prism constants should only be set in the total station or in the data collector. Never set the prism offset in both devices.

Guidelines to properly maintain prisms include:

- Transport and store prisms separately in padded compartments, padded containers, or softcases to prevent damage.
- Do not lay prisms where they might be damaged, for example in the bed of a truck.
- All prisms should be removed from prism poles before storage.
- Clean glass surfaces regularly, using water and a soft towel or specially treated, silicon free lens cleaning tissue.

3.5-4 Global Positioning System Equipment

Field components of GPS survey systems include:

- Receivers
- Data collection system
- Antennas
- Data link system (for real-time positioning)
- Cables
- Accessories (such as tripods, tribrachs, batteries and chargers, rover poles, and other miscellaneous accessories)

GPS Receivers

A typical survey-grade GPS receiver is encased in a durable housing that is lightweight and weatherproof. GPS receivers require line-of-sight reception of the satellite signals and perform best when the antenna has

an unobstructed view of the sky. Ensure that the latest version of the receiver's firmware has been installed. Radio frequency energy from nearby radio, television, or radar transmitters may overpower GPS receiver circuits. Attempt to stay at least a quarter of a mile away from such electromagnetic field sources. Low power handheld radio operations may also interfere with operation of a GPS unit. Use a radio scanner to find a clear frequency, and check for interference.

Antennas and Cabling

Two types of antennas are used with typical GPS units. The geodetic antenna is a high-precision micro-strip antenna with a groundplane used for static GPS surveys. It is mounted on a tribrach/tripod or a fixed height pole with a stabilizing tripod and then precisely centered and leveled over a survey mark or monument for high accuracy GPS measurements. The kinematic antenna, used for kinematic and real-time kinematic GPS surveys, is mounted on a fixed-height rover pole and may be supported by a bipod.

Both types of antennas may be connected to the receiver by a detachable cable. Care must be taken not to kink or pinch this cable. The antennas are completely sealed and weather resistant, and require no calibration or adjustment.

Use the appropriate antenna for the receiver and document the type in the field notes. Mixing antennas of different model or make of GPS receiver systems may induce error or damage the units due to voltage mismatches.

Transport and store antennas only in provided cases.

3.5-5 Leveling Instruments and Rods

Caltrans survey crews are generally equipped with an optical pendulum level or a digital level.

Optical Pendulum Level

Pendulum levels are fast, accurate, and easy to maintain. Proper care and adjustment is required to provide continuous service and to maintain precision in measurement. Never disassemble an instrument in the field. Only make those adjustments outlined in the operator's manual.

Care of a Pendulum Level:

- To prevent compensator damage, do not spin, bounce, or hit pendulum levels.
- Protect the level from dust. Dust or foreign matter inside the scope can cause the compensator damping device to hang up.

Circular Bubble Test and Adjustment: Frequently check adjustment of the “bullseye” bubble. Adjust the bubble to the center of the “bullseye”. Make certain the bubble is adjusted along the line of sight and 90° to the line of sight as well. Proper adjustment reduces the possibility of compensator hang-up. Adjustment will be easier if done in the shade, where temperature is constant.

Horizontal Cross-Hair Test and Adjustment (Two-Peg Test): At least once every 90 days or when discrepancies show up in the leveling work and before every three-wire level survey, the “Two-Peg Test” should be performed as follows:

- Select two benchmarks “A” and “B” approximately 200 feet apart.
- Set up the level midway between the two points “A” and “B”. Record the rod readings of each point determining the difference in elevation.
- Move the level 20 feet beyond either benchmark and record the rod reading of both points again, once again determining their difference in elevation.
- If the difference in elevation measured at each setup is the same, the level is in adjustment. If not, the horizontal cross-hair should be adjusted as detailed in the operator’s manual.
- After the adjustment repeat the “peg test” again to check the adjustment.

Mechanical Functions: To check for proper compensator function, lightly tap the telescope with a pencil or operate the fine movement screw to and fro while watching the cross hairs move and return to their original position. If the compensator is slow to respond or malfunctioning, contact the Office of Land Surveys for a repair work order, and send the instrument to an approved repair facility. There are no mechanical field adjustments that can be made on the compensator.

Digital Level

Digital levels operate by comparing the observed digital image of a bar-code leveling rod with a map of the bar code stored in the level's memory. These instruments are also equipped with a conventional pendulum-type compensator and may be used as an optical level. An on-board computer processes all leveling operations including determination of sight lengths.

A digital level system should include:

- Digital level with data recorder module or cable connection to a data collector
- Data reader and/or appropriate computer interface/cables
- Bar-code leveling rods

Field Operations: At the beginning and end of each day's operation, check the instrument for collimation error, recording the tests into the survey notes. When using digital leveling instruments, the absolute collimation error will be recorded along with the leveling data. If an error in excess of 0.005 foot within a 200 foot sight distance is detected, the level should be readjusted. If the instrument is severely jolted or bumped, or suspected as such, it should be immediately checked.

Manufacturers' specifications state that the digital leveling instrument should not be exposed to direct sunlight and recommend use of an umbrella in bright sunlight.

Horizontal Cross-Hair Test and Adjustment (Two-Peg Test): The test and adjustment procedure for an electronic digital level is geometrically similar to the two-peg procedure for a conventional optical level. However, all horizontal and vertical measurements and differences are measured and recorded electronically. The collimation error is recorded by the on-board computer.

Data Collection, Storage, and Transfer: Raw data generated by a digital level is stored in a data collector and processed into field book format. Software will perform simple or least-squares adjustment of the data.

Leveling Rods

Leveling rods, both conventional and bar-code, should be maintained and checked as any other precision equipment. Accurate leveling depends as much on the condition of the rods as on the condition of the level.

Reserve an older rod for rough work, such as measuring inverts, mud levels, water depths, etc.

Routine Maintenance and Care:

Maintenance procedures common to all types of rods are:

- Periodically check condition of rod for proper function and operation.
- Clean graduated faces with a damp cloth and wipe dry.
- Keep the base plate clean.
- Periodically lubricate hardware and slip joints with an oil-free silicon spray.
- Clean sand and grit from slip joints.
- Periodically check all screws and hardware for proper function.

Transport and Storage:

- Store rods in protective sleeves or cases, in a dry location, either vertically (not leaning), or horizontally. When stored horizontally, either fully support the rod or provide at least three-point support.
- If possible, leave a wet rod uncovered and extended until it is thoroughly dry.

Field Operations:

- Touch graduated faces only when necessary and avoid laying the rod where the graduated face will come into contact with other tools, objects, or materials that could mar the face.
- Do not abuse a rod by throwing, dropping, dragging, or placing it where it might fall. (A leaning rod is a falling rod!)
- Do not lay a rod in sand, dust, or loose granular material.
- Lower rod sections as the rod is being collapsed. Do not let the sections fall or drop.

Direct Reading Rod: At frequent intervals, check all components for wear. If the tape guides begin to snag or bind the tape, have the rod repaired.

Fiberglass Leveling Rod: Spring loaded buttons protrude through precisely matching holes in each section of a fiberglass rod to lock the sections in place while extended. Dowels through the bottom of each section keep the section above from falling inside the lower section when the rod is collapsed. Allowing the sections to free fall when collapsing

the rod will loosen or damage the dowels, causing the sections to jam and may also shatter the fiberglass around the dowels.

Observe the following precautions:

- When a locking button joint goes bad, remove the rod from service.
- Although fiberglass is non-conductive, dust and/or moisture on the surface of a rod can allow electricity to be conducted on the surface of the rod. Use caution when working around power lines.

Invar Leveling Rods: Invar rods are precisely calibrated; extra care is required to maintain this calibration. Observe the following precautions:

- Always use a turning plate (“trivet” or “turtle”) for turning points.
- Never set the bottom plate of an invar rod on the ground.
- Never lay an invar rod on the ground.
- Store, fully supported and stopped, in a water-proof case.
- Do not use invar rods in rain or dust.
- Carry parallel with the ground, in alternate “face-up” and “face-down” positions to equalize weight stresses.
- If foreign matter has “fouled” a rod, carefully remove the material and clean.
- The rod tape must slide freely in the recessed guides as the staff expands or contracts.

3.5-5 Survey Instrument Accessories

Tripods: Tripods support and provide a fixed base for all types of surveying instruments. The typical tripod used for Caltrans Surveys has a 5/8-in. x 11 thread fastener to secure an instrument, antenna, or accessory to the tripod head. The head provides a lateral adjustment range for the instrument or tribrach of approximately 1 inch. The tripods are of a wide-frame design and have extendible legs. For precise leveling, use a fixed leg tripod.

A secure and stable tripod is required for the support of precision instruments. There should be no slack between the various components of a tripod. Loose joints or fittings will cause instability.

Some guidelines to properly maintain tripods are:

- Maintain proper torque on all metal fittings. Over-tightening is the cause of crushed components and stripped threads.
- Tighten leg hinges just enough to support the fully extended legs when a tripod is lifted clear of the ground.
- Keep the metal tripod shoes tight and free of dirt and debris.
- Keep wooden parts of tripods well-painted or varnished to reduce swelling and shrinking due to moisture content of the wood.
- Always replace top caps when tripod is not in use to protect the mounting surface and head from damage.
- Use care when placing or removing tripods from the survey vehicle, as significant damage can occur. Ensure that carry compartments are designed and constructed to isolate tripods from each other and from other equipment.

Tribrachs: Tribrachs are the detachable base for most survey instruments and many accessories. They are equipped with an optical plummet and spherical “bullseye” level. The ability to “leapfrog” instrument setups by interchanging instruments, prisms, targets, or antennas without disturbing the setup of a tribrach greatly enhances the speed, efficiency, and accuracy of a survey.

Some guidelines to properly maintain tribrachs are:

- Transport tribrachs in separate compartments or containers to prevent damage to the base surfaces, spherical level and optical plummet.
- Do not over-tighten the tripod fastener screw.
- Do not over rotate the leveling screws
- Do not over rotate the optical plummet focusing knob
- Clean leveling screws regularly.
- When tribrachs are not in use, set leveling screws at mid-range, usually marked by a horizontal line.
- Use care whenever using range poles mounted on a tribrach to vertically extend a sight, antenna, or prism. Extensions place considerable stress on the leveling plate.
- Adjust spherical “bullseye” level and vertical collimation of optical plummet routinely.

Prism/Rover Poles: An attached adjustable spherical “bullseye” level bubble is used to maintain a prism/rover pole in a vertical position. A maladjusted level bubble may cause systematic error when using the pole. Jigs are available for checking and calibrating prism/rover poles.

3.6 Computer Systems

To effectively process the large volume of electronic data produced by Caltrans survey crews, each Surveys office should be equipped with adequate computing, storage, and printing equipment.

3.6-1 Office Computer Systems

Each Surveys office employee should have access to a personal computer with sufficient processing and memory capability to fully use currently supported design/survey processing software.

3.6-2 Field Computer Systems

Each survey party should be equipped with a laptop personal computer. The computer should have processing and memory capability to fully utilize supported surveying software. Survey party computer systems are issued to the Districts/Regions by the Office of Land Surveys. For information on upgrades and service and repairs, contact the Office of Land Surveys.

3.6-3 Caltrans Policy Regarding Use of State Computer Systems

Use of Caltrans computer equipment for personal business is subject to adverse action. For more detailed information on this policy, see the current Directors' Policies and Deputy Directives concerning computer usage and information technology.

3.7 Vehicles

Care and operation of State-owned vehicles are detailed in the Department's *Equipment Manual* and in Board of Control rules. Many of the *Equipment Manual* instructions, especially those dealing with operation and emergency service, are summarized in the booklet, *Operation, Accident and Emergency Service Information*. This booklet is in the "Vehicle Accident Reports" envelope in the glove compartment of all State vehicles. All employees who drive State-owned vehicles should familiarize themselves with the contents of this booklet.

The appropriate Hourly Vehicle Log or Mileage Vehicle Log and the Daily Pre-Operation Report must be completed each day that a vehicle is used.

Vehicle operation and care are joint responsibilities of all survey field crewmembers. Some of these responsibilities are:

- Use of seat belts by all.
- Use of defensive driving techniques.
- Observance of all State and local vehicle regulations.
- Operation within the physical and mechanical limitations of the vehicle.
- Compliance with the Preventative Maintenance (PM) policies.

Guidelines for safe motor vehicle operation are found in Chapter 17, "Motor Vehicle Safety" of the *Caltrans Safety Manual*.

3.7-1 Misuse of Vehicles

Use of a State owned vehicle for personal business is subject to adverse action. For details see Section 17.12, "Misuse of State-owned Motor Vehicles" of the *Caltrans Safety Manual*.

3.7-2 Home Storage of State Vehicles

Home storage of Caltrans vehicles is permitted in cases when secure Caltrans storage for vehicles is not available and when it is more efficient to store vehicles at home so that employees can begin the workday at the job site. Home storage is not allowed to enable employees to commute in State-owned vehicles. A Home Storage Permit is required for employees on State business who drive and store a State vehicle at home at least 36 nights in three months or 72 nights in one year. To obtain applications and requirements for Home Storage Permits, contact the District Automotive Manager. Permits must be reviewed for renewal on an annual basis.

3.7-3 Security of Vehicles

The operator or user of a State vehicle is responsible for the security of the vehicle and its contents when parking or storing it. The following security precautions should be followed:

- Remove ignition keys; close and lock all windows, doors, and compartments.
- Store survey instruments and other valuable equipment, such as laptop computers, during times of non-use in a “double-locking” compartment. A “double-locking” compartment is defined as being secured with two separate locking devices, usually a lockable handle and an additional deadbolt or hasp and padlock. Survey instruments and computers should be removed from the vehicle, and stored in a secure location outside of working hours.
- Park off the street whenever possible. In residential areas you must park off the street unless specifically authorized to do otherwise.
- Leave vehicle in “low” or “reverse” in manual transmissions, or “park” in automatic transmissions and with the emergency brake firmly set. If parked on a grade, turn the front wheels to roll into the curb or off the road.

3.7-4 Off-Road Operations

Four-wheel-drive vehicles are equipped for use in rough terrain or adverse driving conditions that make travel in two-wheel drive vehicles hazardous or impossible. Not all four-wheel-drive vehicles operate in the same manner. Consult the operator's manual for appropriate operation of a particular make and model of vehicle.

Some guidelines for the proper use of four-wheel-drive vehicles are:

- Do not wait until there is a problem to use four-wheel drive.
- Make certain the transfer case and the front drive hubs are engaged.
- Do not engage the low range without having the hubs in locked positions.
- Keep your speed below 25 mph when in four-wheel drive.
- Do not drive on pavement in four-wheel drive.
- Avoid side-hill operations.
- Secure all equipment before traveling on rough or difficult terrain.

3.7-5 Obtaining Fuel, Service, and Parts

Whenever feasible, fuel, service, and parts must be obtained from a State facility or contractor. Make an effort when purchasing fuel, service, and parts from a commercial facility to obtain the lowest possible cost for the state.

Purchases from commercial vendors for State vehicles should be made using the State gas credit card. Before using the State gas credit card, check for acceptance prior to delivery of the product or service. The operator of a State vehicle must assure proper credit card usage.

Consult with the Equipment Shop or traveling mechanic by telephone or radio before committing the State to emergency purchases. Submit written justification, along with the receipt or invoice of charges, for any emergency purchases.

3.7-6 Preventive Maintenance

Preventive maintenance is a regularly scheduled program of checks, inspections and services designed to provide maximum uptime and to prevent unsafe or untimely failures of equipment.

A program of preventive maintenance (PM) shall be followed for each survey vehicle. This program and pertinent procedures are covered in the Equipment Service Center's July 1, 1995 memo revising the July 13, 1994 *Mobile Equipment Preventive Maintenance Guidelines*.

The PM program includes:

- Daily pre-operation inspection and reporting using the Daily Pre-operation Inspection Booklet (DME - 151).
- Regular preventive maintenance and inspections as required.
- Use of the Permanent Equipment Maintenance Record Book for all vehicles.

3.7-7 Using Privately-Owned Vehicles for State Business

Use of privately-owned vehicles on State business may be permitted if advantageous to the State or if a State vehicle is unavailable. For instructions and rules for the use of privately-owned vehicles for State business, see the *Caltrans Travel and Expense Guide*, Chapter 3, "Private Vehicle Use."

Advance authorization is required for use of a privately-owned vehicle on State business. Authorization is obtained by filing Form FA0205A, "Authorization To Use Privately-Owned Vehicles on State Business." This form must be filed annually.

Privately-owned motorcycles are not authorized for use on State work.

3.8 Radio Communication Systems

Good communications are essential to efficient and safe surveys operations. Surveys employees must utilize the Caltrans radio communications system properly, as the system is operated under a license from the Federal Communication Commission (FCC). Violation of FCC rules could result in loss of frequency privileges.

The primary statewide system consists of more than 10,000 mobile units and some 1300 base stations. (Mobile units include radio-equipped vehicles and portable, hand-held radios). It is classified as a mobile radio system. Base stations are usually located at district offices and the offices of maintenance superintendents and resident engineers. Transmitters and repeater stations are located on mountain tops to obtain greater range.

Survey field crews use the statewide mobile radio system for communication with the District Surveys office, other field crews, and individuals on the same crew. Shorter range hand-held radios are preferred for communication between members of the same survey crew. Due to frequency mismatches, some vehicle-mounted mobile radios cannot interact with the hand-held radios.

For more detailed information on the Caltrans radio system, see the *Caltrans Radio Operator's Manual*.

3.8-1 Purchase and Service

Caltrans statewide radio equipment is obtained and serviced by the Caltrans Telecommunications Section. Contact the District Telecommunications Manager to obtain new systems or when existing systems require service.

Short range hand-held radios may be provided by the Office of Land Surveys. Contact the Office of Land Surveys for service or repairs.

Do not automatically assume that your radio is at fault when you are unable to communicate with a desired station. The other radio, associated control equipment, or repeater station might be defective. Also, the operator of the other radio might be temporarily away from the radio; you could be out of range or in a “dead” spot; or the other radio might be turned off.

3.8-2 Transport and Storage

Radios should be kept in their carrying case at all times. Avoid laying a radio in precarious places where it could be dropped or knocked to the ground. Never pick-up a hand-held radio by its rubber antenna. Also, do not clip the microphone to the radio antenna.

3.8-3 Field Operations

Precautions to be taken when using radios are:

- All messages should be as short and to-the-point as possible.
- Speak in plain language at a moderate rate, using words with a clear definition, while holding the microphone close to, but not touching, the mouth.
- Pause and listen before you push the transmit button.
- Do not break into ongoing conversations unless your transmission is an emergency.
- Portable radios should never be left laying in direct sunlight for extended periods of time.
- Never transmit near blasting operations without first receiving clearance from the person in charge.
- Trade off hand-held radios so that one is not used exclusively for transmitting, as lengthy transmissions require considerably greater battery discharge than receiving only.
- Battery life of the receiving hand-held radio may be extended by simply clicking the transmission button to acknowledge receipt of a message.

3.8-4 Improving Radio Transmission Quality

Radios do not always work equally well in all directions. Because of terrain or obstructions, radio transmissions may be directional. If you are unable to communicate with a desired station (unit), try the following:

- Turn your radio to face another direction.
- Change location (sometimes only a few yards helps).
- Move to a higher elevation (an overpass can sometimes help).

Appendix 3A: Survey Party Equipment List

The following is a list of assorted equipment, tools, and materials available to a Caltrans survey crew. Not every item on the list will be assigned to each crew. This list may be modified when performing non-routine surveys or when operating in remote locations.

Equipment List for Caltrans Survey Crew

QuantityDescription of Item

1 each.	Electronic Total Station Survey System including data collection device and batteries
1 each.	GPS RTK system including Base to Rover data link
1 each.	Digital level and “bar code” rods
1 each.	Automatic optical pendulum level
2 each.	Calculators with pre-programmed COGO
1 each.	Laptop PC capable of running approved survey software
1 each.	Computer printer (portable, ink jet)
1 each.	Cellular telephone
5 each.	Tripods
5 each.	Tribrachs
1 each.	Tribrach level-bubble-adjusting block
1 each.	Tribrach optical-plummet-adjusting cylinder
5 each.	Single prism assemblies and stems
1 each.	360° prism
2 each.	Triple prism assemblies and stems
1 each.	Extended-range multiple (11) prism assembly
2 each.	Standard extendible prism poles
2 each.	15 foot layout/prism poles
3 each.	25 foot fiberglass rods with prism adapters
1 set.	Matched geodetic leveling rods
2 each.	Direct reading elevation rods
assortment.	Fiber and steel tapes (12-100 feet)
4 each.	Plumb bobs
2 each.	Barometer and thermometer
5 each.	District 2 ‘Zekes’ (rubber pucks with slots that hold plastic reflectors for taking pavement shots)
1 each.	Rola-Tape wheeled measuring device
1 each.	Magnetic field pipe (monument) locator
1 each.	Battery charging/cycling device
1 per person.	Handheld FM two-way radios
1 each.	Programmable handheld radio with appropriate District/Region Surveys and/or Maintenance and Construction frequencies
1 each.	Telescoping pole saw
1 each.	Camera (Digital or film)

Equipment List for Caltrans Survey Crew, continued**QuantityDescription of Item**

1 each	.....First aid kit (16 unit)
14 each	.....Traffic cones
12 each	.....Warning flags
2 each	.....Hand-held “Stop/Slow” paddles
2 sets	.....“Survey Crew Ahead” signs
1 each	.....Drinking water cooler (5-gallon)
1 each	.....Traffic accident surveillance & analysis system (TASAS) listing
1 each	.....District/Region post mile map
1 each	.....District/Region list of emergency and medical facilities (phone numbers and locations)
assortment	.....Insect repellent
assortment	.....Anti-tick release and removal kit
assortment	.....Safety glasses (gray, amber and clear)
assortment	.....Ear protection devices
assortment	.....Gloves (both leather and cloth types)
assortment	.....Toxic vegetation barrier cream
assortment	.....Wooden stakes
assortment	.....Plastic construction staking cards
assortment	.....Rebar, 30-inch and 18-inch long, with aluminum caps
assortment	.....Galvanized iron pipe, 30-inch and 18-inch long, with plastic plugs
assortment	.....Brass caps and brass caps on iron pipes
assortment	.....Impact tools for brass cap on rebar, and pipe
assortment	.....Hand tools (hammers, gads, wrenches, etc.)
assortment	.....Cutting tools (machetes, axes, hatchets, etc.)
assortment	.....Ribbon flagging (various colors)
assortment	.....Nails (100 d spikes, 16d nails, asphalt pavement nails, concrete nails, etc.)
assortment	.....Writing materials (pens, pencils, markers, etc.)
assortment	.....Drafting tools (triangles, symbol and arc templates, various scales, etc.)
assortment	.....Note forms (grid, survey, etc.)
assortment	.....Paint (white, orange, black, green, etc.)
assortment	.....Digging tools (shovels, picks, digging bars, etc.)
assortment	.....Large clear plastic garbage bags to protect equipment from inclement weather.
2 each	.....Whisk broom
assortment	.....Various size die stamping sets
assortment	.....Hard hat liners and gloves for protection from cold
1 copy each	.....Surveys Manual; Safety Manual; Manual of Traffic Controls; and Chapter 8, “Protection of Workers” of the Maintenance Manual
1 set	.....Snow chains
1 set	.....Jumper cables
1 box	.....Warning flares
2 each	.....Staplers (gun type for staking cards and a standard office stationery type)
assortment	Office and stationery supplies (rubber bands, paper clips, envelopes, etc.)